Ovenized Inertial Micro Electro Mechanical Systems

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Description:
There is a critical DoD need for capabilities that focus on temperature stabilization of MEMS inertial sensors to improve bias and scale factor stability. Military operations rely on satellite-based Global Positioning System (GPS) for precision Positioning, Navigation & Timing (PNT) information. However, GPS is an extremely small signal, which may be degraded due to signal interference or obstructed by environmental factors such as clouds, urban canyons or other impeding structures [1]. In GPS-degraded environments critical PNT information must be gathered from alternate sources, such as navigation by the technique of dead reckoning based on acceleration and rotation inputs from an Inertial Measurement Unit (IMU) [2]. IMUs based on Micro Electro Mechanical Systems (MEMS) are low Cost, Size, Weight, and Power (CSWaP), but typically exhibit high calibration environmental sensitivity, particularly to external temperature variation [3,4]. MEMS sensors are early in their development; they have made their way into consumer market but underlying limits to sensitivity and stability are not well understood. This is analogous to the development of crystal oscillators (XO) developed early in the 20th century. Over the past century, temperature sensitivity of crystal oscillators has been improved by applying temperature compensation algorithms based on the externally sensed ambient temperature (TCXO) [5]. However, the best performing crystal oscillators rely on ovenization of the resonant device to provide the highest stability (OCXO)[6]. The evolution of MEMS-based inertial sensors is likely to follow a similar trajectory due to the similarity of vibrating MEMS devices to quartz oscillators. At present, uncompensated MEMS inertial sensors are widely available for commercial applications and digital temperature compensation (TC-MEMS) devices are emerging [7]. Temperature stabilization has been demonstrated to improve long-term stability and

reproducibility of MEMS inertial sensors in an academic setting but has yet to be transitioned into marketable MEMS-based inertial sensors [8]. This SBIR seeks to develop Ovenized Inertial MEMS (OI-MEMS) with a viable path to commercialization. PHASE I: Design a concept for achieving tactical grade inertial sensor performance, as listed below. The sensor should operate on 500mW in a 0.5cc package. Phase I deliverables will include: a fabrication flow process, and a detailed analysis of predicted performance metrics. Bias Stability over temperature (-40 to +85°C) • Gyroscope: 1°/hr • Accelerometer: 1 mg Scale Factor Stability over temperature (-40 to +85°C) • Gyroscope: 10 ppm • Accelerometer: 1 ppm ARW • Gyroscope: 0.125°/rt(hr) • Accelerometer: .5 ft/s/rt(hr) PHASE II: Develop, demonstrate, and validate Phase 1 model predictions; refine fabrication procedures to fine tune thermal expansion and coefficient second-order effects; conduct life cycle and environmental testing to verify performance; manufacture and deliver gyroscope or accelerometer prototypes for government evaluation. Required Phase II deliverables include 5 packaged sensors with necessary electronics to operate the Ovenized Inertial MEMS device. PHASE III: The military need for PNT information in the absence of GPS is in very high demand. Current DARPA programs are pursuing self-contained navigation for applications such as missile guidance, mounted and dismounted soldier navigation in GPS denied environments. Much progress has been made in existing microPNT programs. This SBIR will complement those efforts, by addressing the key driver of long-term instability with a fast track to commercialization. Due to the high performance of the OI-MEMS, there is limited commercial application. However, there is a market for high performance, small CSWaP inertial sensors for oil drilling and agricultural applications.